Fast evaluation of the reflection from a temporally switched Dallenbach screen

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In this work we explore the electromagnetic absorption and scattering of a short time pulse that normally impinges a time – varying Dallenbach screen [1]. A Dallenbach screen is composed of a lossy magneto – dielectric layer that is sandwiched between half space of vacuum and a perfect electric conductor sheet. For such layout and for time harmonic wavefield, there exist an analytic bound on the maximal absorption [2]. Recently it was shown that for a pulsed wave field signal this bound can be bypassed under the assumption that the electromagnetic characteristics of the layer, namely the permittivity, permeability and conductivity are allowed to change abruptly or gradually with time [3]. For, a short-time pulsed wave field that impinges the absorbing layer with parameters $(\epsilon_1, \mu_1, \sigma_1)$ at time $t = 0$, part of it is back reflected and part of it propagates into the layer. At $t_s > 0$, while the pulse wavefield is within the layer the electromagnetic parameters of the layers are abruptly switched into a new set of values $(\epsilon_2, \mu_2, \sigma_2)$. In order to solve for the field distribution for $t > t_s$, an initial value problem is solved where continuity of fluxes at $t = {t_s}^+$ set the initial conditions following the switching. For $t > t_s$, the field inside the layer propagates and bounce back and forth between the two interfaces, where some of it is absorbed by the layer, while the rest of it is scattered back to the vacuum.
In order to trace the the time domain fields, a transmission – line (TL) modeling used. This model is formulated in the complex Laplace temporal frequency variable s followed by an inverse Laplace transform. Here, we prove that the spectral Green's function in the complex temporal domain s does not acquire any branch point or branch cut singularities, but exhibits only simple pole singularities. This feature enables us to use Jordan's lemma and to sum residues of simple poles instead of performing a numerical integration that is computational heavily. Since there exist infinite number of poles, we practically use only a finite number of them. This process yields a semi-analytic expression for the reflected field that is dependent on the location of the complex poles which is found using the iterative Newton-Rapshon algorithm. The above description is valid for cases where the characteristic impedance of the switched layer is different from the vacuum, i.e. $120\pi[\Omega]$ and for a normal incidence.
A numerical example with a modulated Blackman impinging pulse is demonstrated such to explore for variety of short time pulse characteristics. A comparison of the time domain fields using different schemes (by direct evaluation of the inverse Laplace transform integration and by summation over residues of simple poles) is given. It is shown that the later approach is capable to accelerate the calculation tens of times with a negligible relative energy error in the order of $O(10^{-10})$. Therefore, this approach can be applied efficiently in optimization algorithms for specific magnetic-dielectric slab designs. These issues will be discussed and demonstrated in the talk.

References

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